Technical Memorandum

To:	Javier Toro Rosemont Copper Company Tucson, Arizona	**Project No:** 1720214024	
By:	Peter H. Yuan, PE, PhD Ray Markley, PE	**Reviewed by:**	Donald East Tony Freiman, PE
Tel:	(602) 733-6000	**CC:** File	
Date:	March 24, 2022		
Re:	**Stability Analysis Memorandum Heap Leach Facility (HLF) Rosemont Copper World Project**		

Executive Summary

The slope stability factors of safety for the Heap Leach Facility (HLF) for the Rosemont Copper World Project (Project) meet or exceed the acceptance criteria as required by the Arizona Department of Environmental Quality (ADEQ) Best Available Demonstrated Control Technology (BADCT) manual (ADEQ, 2004) for all cross sections evaluated. Critical cross sections of the facility side slopes were modeled using Slide2 9.019 (Rocscience, 2021) limit equilibrium software to assess slope stability under static and earthquake conditions (pseudo-static). The design seismic event with a return period of 2,475 years was selected for the HLF.

The proposed HLF will be constructed to a maximum slope height of about 430-feet (ft) (maximum vertical height of side slope between the crest and toe) and with a maximum overburden height (vertical distance between the crest and basal liner) less than 400-ft. The HLF would be constructed using end dump or conveying methods with lifts of 30-ft, stacked at the angle of repose, with benching to create an overall slope of 2.3 horizontal to 1 vertical, (or 23.5 degrees). Both run-of-mine (ROM) and crushed ores will be stacked in the proposed HLF. The foundation materials range from weathered rock to about 80-ft of alluvial or colluvial soils overlying weathered rock., along with waste rock that is to be placed prior to the construction of the HLF. These materials are dense and dry enough such that the possibility of liquefaction of the foundation or of the leach ore is very low given the tectonic environment of the Project area. No collapse susceptible soils were encountered within the HLF foundation area during investigations. The locations of the cross sections analyzed are shown in Figure 1-1 and the cross sections themselves are presented on Figures 4-4 through 4-15.

1.0 Introduction

1.1 Purpose

Wood Environment and Infrastructure Solutions, Inc. (Wood) has prepared this technical memorandum for Rosemont Copper Company (Rosemont) to addresses the stability analyses in support of the Aquifer Protection Permit (APP) Application and Pre-Feasibility Study (PFS) Leve Design Phase of the HLF for the Rosemont Copper World Project (Project) in accordance with requirements of ADEQ and Arizona Mining BADCT Guidance Manual (ADEQ, 2004).

The use of BADCT to minimize the impacts to groundwater is required by ADEQ to obtain an APP for the planned heap leach pad (HLP). BADCT is to be applied throughout the entire facility life cycle including design, construction, operation and closure. Engineering analyses were performed in general accordance with requirements for the APP, Arizona Revised Statute (A.R.S.) 49-243.B.1 and followed the individual BADCT criteria.

The data presented in this memorandum summarizes the limit equilibrium slope stability analyses performed to assess the slope stability of the HLF planned to support the Project. Both static and pseudo-static analyses were performed using the Slide2 9.019 (Rocscience, 2021) computer program to perform limit equilibrium slope stability using the Morgenstern-Price's method (1965) of slices.

1.2 Background Information

Numerous reports and BADCT demonstrations have been prepared as part of the previous permitting process for the Rosemont Copper Project including the following key studies related to design of the HLF:

- Geotechnical Study Report, presenting initial geotechnical site investigations conducted in 2006-2007 at the Rosemont Copper Project (Tetra Tech, 2007a);
- A HLF design in support of a feasibility-level design of the Rosemont Copper Project (Tetra Tech, 2007b);
- An addendum to the 2007 Geotechnical Study Report (Tetra Tech, 2009a);
- A 2009 permit-level design report for HLF (Tetra Tech, 2009b);
- A HLF foundation settlement analysis (Tetra Tech, 2010a); and
- A supplemental liner leakage calculation (Tetra Tech, 2010b).

Wood has completed geotechnical investigations and laboratory testing in and near the Tailings Storage Facilities (TSFs)/Heap Leach Facility (HLF)/Waste Rock Facility (WRF) sites as part of the design process (Wood, 2021a). The investigation included field mapping, test pit excavation, borehole advancement, field and laboratory testing and insitu and potential borrow source materials. The historical and new data forms the basis of the TSF/HLF/WRF designs. In addition to the field and laboratory investigation, samples of potential borrow materials were collected and tested from within the Project area, with potential overliner material sourced from the Peach Pit area.

In lined areas of the HLF, the liner will consist of the following components from bottom to top (Figure 1-2):

- Subgrade foundation materials consisting of competent rock overlain (in some areas) by weathered and altered rock which is covered by varying thicknesses of colluvium and soils, along with compacted (engineer-controlled) waste rock to be placed within most of the HLF footprint area.
- Underliner or Liner Bedding Material: A layer of geosynthetic clay liner (GCL) is currently planned.
- The underliner is overlain by a geomembrane: The geomembrane will consist of 80-mil double sided textured linear low-density polyethylene (LLDPE).
- The overliner will consist of a three-foot thick layer of a well-draining material installed over the geomembrane. The overliner material will be obtained from processed ore consisting of 1.5-inch minus rock with a hydraulic conductivity of $1x10^{-1}$ centimeters per second (cm/sec) or higher. There will also be a series of perforated solution collection pipes directly above the geomembrane which are sized and spaced to minimize the hydraulic head on the liner.

2.0 BADCT Criteria

2.1 General

The operation of a HLF in the State of Arizona requires that the facility be permitted under the promulgated APP program. The construction of the HLP requires that a permit be issued by the State of Arizona. The construction and operation of the dam should follow the BADCT for a specific mining facility type and site in accordance with A.R.S 49-243.B.1.

This statute requires all permitted facilities to utilize BADCT in their design, construction and operation while considering various factors depending on whether the facility is new or existing.

The requirements of BADCT are met, according to A.R.S. 49-243.B.1, if it is demonstrated:

> That the facility will be so designed, constructed and operated as to ensure the greatest degree of discharge reduction achievable through application of the best available demonstrated control technology, processes, operating methods or other alternatives, including, where practicable, a technology permitting no discharge of pollutants. In determining best available demonstrated control technology, processes, operating methods or other alternatives, the director shall take into account site specific hydrologic and geologic characteristics and other environmental factors, the opportunity for water conservation or augmentation and economic impacts of the use of alternative technologies, processes or operating methods on an industry-wide basis. However, a discharge reduction to an aquifer achievable solely by means of site-specific characteristics does not, in itself, constitute compliance with this paragraph. In addition, the director shall consider the following factors for existing facilities:
>
> *(a) Toxicity, concentrations and quantities of discharge likely to reach an aquifer from various types of control technologies.*
>
> *(b) The total costs of the application of the technology in relation to the discharge reduction to be achieved from such application.*
>
> *(c) The age of equipment and facilities involved.*
>
> *(d) The industrial and control process employed.*

(e) The engineering aspects of the application of various types of control techniques.

(f) Process changes.

(g) Non-water quality environmental impacts.

(h) The extent to which water available for beneficial uses will be conserved by a particular type of control technology.

Arizona Administrative Code (A.A.C.) R18-9-A202(A)(5) requires that an application or major modification for an APP include a description of the BADCT to be employed at the facility. The procedures and information presented in this guidance manual are intended for use in determining the appropriate BADCT, and to assist the applicant's development and the ADEQ's review of permit applications.

2.2 Prescriptive and Individual BADCT Permitting

As aforementioned, BADCT should be applied throughout the entire facility life cycle including design, construction, operation and closure. As promulgated, two general approaches to demonstrate BADCT are possible:

Prescriptive BADCT requires evaluating and selecting a pre-determined discharge control technology as the BADCT design. Typically for new precious and base metal heap leach facilities, this requires a composite liner consisting of a single geomembrane of at least 60-millimeter (mil) HDPE underlain by a minimum of one (1) ft of compacted soil with a saturated hydraulic conductivity less than 10^{-6} meters per second (m/s). The geomembrane should be covered by a protective drainage layer with a minimum thickness of 1½ foot consisting of a ¾ inch minus well-draining material. Additionally, the drainage layer should have corrugated perforated high-density polyethylene (HDPE) pipes of three (3) inches (75 mil) or larger diameter at 20-ft (six meters) spacing. The drainage layer should flow by gravity to a low point where the fluids can be removed, thereby minimizing the hydraulic head over the liner.

Individual BADCT establishes a reference design incorporating a combination of demonstrated control technologies which are appropriate for the site and then evaluating the aquifer loading potential for the reference design and alternative designs. The practical design resulting in the lowest significant pollutant load to the aquifer would be selected as the BADCT design. Individual BADCT development may be based on considerations of waste characteristics, site characteristics (hydrology, hydrogeology, etc.), design measures, operational features and closure methodology.

3.0 Heap Leach Facility Design (HLF)

The pre-feasibility-level engineering design of the HLF considered field and laboratory test data from the geotechnical investigation and historical data as listed in Section 1.0. Subsurface conditions for the stability model were developed from field data presented in the Geotechnical Site Investigation Memorandum (Wood, 2021a) and studies listed in a previous Rosemont APP. Material properties used in the analysis were developed from the engineering material shear strength data based on the field and laboratory investigations, the literature, and Wood's experience with similar materials.

Key assumptions in regard to developing the limit equilibrium models and slope stability calculations include the following:

- Stacking of HLF will be performed as shown on the figures with an overall slope of 2.3 to 1 (horizontal to vertical).
- The overall downgradient liner subgrade underneath the heap side slopes is no steeper than 6.5 percent (%).
- Pond's downstream side slope is designed at 2H:1V and upstream slope is designed at 2.5H:1V.
- High hydrostatic forces should not develop within the HLF due to the free drainage characteristics of the HLF. Gradation, durability, and permeability of ROM and crushed ore materials under leaching have yet to be characterized in future studies.

4.0 Stability Analyses

Two-dimensional limit equilibrium method of slices was used to analyze the stability of the subject facilities under static and earthquake (pseudo-static) conditions. Stability analyses considered the end of the Project when the material depositions are filled to the respective final configurations. See Figure 1-1 for cross sections analyzed.

4.1 Limit Equilibrium Method

A series of stability analyses were performed using Slide2 9.019 (Rocscience, 2021), a commercially available computer program which enables the user to conduct limit equilibrium slope stability calculations by a variety of methods and search routines. For the failure mechanisms considered in the analyses, the slope stability was evaluated using limit equilibrium methods based on Morgenstern-Price's method of analysis (Morgenstern-Price, 1965). Morgenstern-Price's method is a method of slices (consideration of potential failure masses as rigid bodies divided into adjacent regions or "slices," separated by vertical boundary planes) that satisfies both moment and force equilibrium. Both circular and non-circular (linear) failure surfaces were evaluated.

The method used to evaluate the stability of the HLF was based on the principle of limit equilibrium (i.e., the method calculates the shear strengths that would be required to just maintain equilibrium along the selected failure plane, and then determines a safety factor (or factor of safety, FoS) by dividing the available shear strength by the equilibrium shear stress). Consequently, safety factors calculated by the limit equilibrium method indicate the percent by which the available shear strength exceeds, or falls short of, that required to maintain equilibrium. Therefore, safety factors in excess of 1.0 indicate stability and those less than 1.0 indicate instability, while the greater the mathematical difference between a safety factor and 1.0, the larger the margin of safety (for safety factors in excess of 1.0), or the more extreme the likelihood of failure (for safety factors less than 1.0).

Slope failure geometries were evaluated considering both circular and non-circular slide surfaces and under both static and simulated earthquake (pseudo-static) analyses. The foundation materials will be composed of either weathered rock, or alluvium, or compacted fill overlying competent rock which is dense and unsaturated making the possibility of liquefaction very low given the tectonic environment of the site.

For the HLF, stability analyses were performed assuming a perched piezometric surface above the liner. The piezometric surface was assigned to the overliner only; and massive saturation zones should not develop within the HLF due to the free drainage characteristics of leach ore. The foundation materials will remain unsaturated. Excessive pore pressures are not anticipated and should not affect the stability of the HLF.

Stability analyses were performed for circular, and non-circular surfaces using a variety of search methods. These methods provide powerful algorithms in which the search for the lowest safety factor is refined as the analysis progresses. An iterative approach is used, so that the results of one iteration, are used to narrow the search area on the slope in the next iteration.

The acceptance criteria based on ADEQ BADCT manual (ADEQ, 2004) requires a minimum FoS of 1.3 under static analyses and 1.0 for pseudo-static analyses, consistent with the HLF design of a previous Rosemont APP (Tetra Tech, 2007b, 2009b).

4.2 Earthquake (Pseudo-Static) Slope Stability Coefficient

Pseudo-static-based analyses are commonly used to apply equivalent seismic loading on earthfill structures. In an actual seismic event, the peak acceleration would be sustained for only a fraction of a second. Actual seismic time histories are characterized by multiple-frequency attenuating motions. The accelerations produced by seismic events rapidly reverse motion and generally tend to build to a peak acceleration that quickly decays to lesser accelerations. Consequently, the duration that a mass is actually subjected to a unidirectional, peak seismic acceleration is finite, rather than infinite. The pseudo-static analyses conservatively models seismic events as constant acceleration and direction (i.e., an infinitely long pulse). Therefore, it is customary for geotechnical engineers to take only a fraction of the predicted peak maximum site acceleration when modeling seismic events using pseudo-static analyses (Hynes-Griffin and Franklin, 1984). The pseudo-static analysis incorporated a pseudo-static coefficient of 0.04g which is 1/2 of the design Peak Ground Acceleration (PGA) of 0.07g (corresponding to the 2,475-year return period), in accordance with the design criteria and Hynes-Griffin and Franklin (1984).

A site-specific seismic hazard study was performed by Lettis Consultants International (LCI, 2021). The design seismic event with a return period of 2,475 years was selected for the HLF, which is more conservative than the Maximum Probable Earthquake (MPE) that was used previously for the Rosemont HLF designs (Tetra Tech, 2007b and 2009b).

The pseudo-static analyses were used to determine the FoS under simulated earthquake conditions. The pseudo-static FoS limit equilibrium slope stability method is used as a screening tool to determine if more rigorous dynamic analyses is needed to model the stability of the facility slopes under earthquake conditions. More detailed deformation analyses would be required if the slope stability factors of safety did not meet the acceptance criteria (less than 1).

Cyclic softening or liquefaction are not anticipated at the Project site given the subgrade and HLF and subgrade will not be saturated, the HLF ore is composed of free draining material and the foundation is composed of either compacted fill or relatively thin layers of dense alluvium overlying competent rock or competent weathered rock. All loose or soft native material (if present within the facility footprint) will be removed or reworked during preparation of the subgrade prior to receipt of engineered materials. Waste rock placed underneath the HLF will be compacted and capped with a protective layer prior to deployment of GCL. The seismicity of the site is also relatively low as explained the site-specific seismic hazard study (LCI, 2021).

4.3 Cross-Section Geometry

Typical HLF geometry consists of four main components: (1) native soils, bedrock, and waste rock, (2) the liner system along the base of the HLF, and (3) leach ore. The modeled cross sections incorporate the design grades of the foundation, liner systems and includes the ore stacked at an overall slope angle of 2.3H: 1V (23.5 degrees). The cross sections were selected to model some of the highest slopes of the HLF and have maximum overburden heights of less than 400-ft.

Three representative cross sections were developed and evaluated as part of this study along the HLF side slopes and pond slopes; these include HLF01, HLF02 and POND01 shown on Figure 1-1. The critical cross sections were selected based on their location considering the steepest basal topography and the highest HLF stacking or pond heights. Three HLF ponds, including pregnant leach solution (PLS) Pond, South HLF Stormwater Pond, and North HLF Stormwater Pond, have similar configurations, and Section POND01 is representative for stability evaluation of these ponds; both downstream slope and upstream slope of the ponds were evaluated.

Figure 1-1 provides a plan view of the HLF layout showing the locations of selected critical cross sections. The slope geometries of the cross sections used in this analysis are provided in Figures 4-4 through 4-15.

4.4 Material Properties

The materials included in each analysis include the shallow rock foundation overlain by variable amounts of native soil, waste rock and engineered fill, which is overlain by the liner system, overliner, and ore material. Material strengths have been developed as part of the BADCT demonstrations in a previous Rosemont APP application. Some of these properties were used to develop the material properties for the stability analyses performed herein. Tetra Tech (2007b; 2009b) presented data from many shear tests of liner interfaces, and other geotechnical characterization data, to develop shear strength envelopes for these materials.

The foundation material consists, in general, of sands and gravels with small varying amounts of silt or clay, varying amounts of cobbles, boulders, highly to completely weathered rock, and moderate to slightly weathered rock. In order to simplify the model assumptions and material properties, the foundation material was conservatively considered to be an alluvial/colluvial soil for the entire foundation depth evaluated. The foundation soil within the HLF footprints was generally logged as dense to very dense and coarse grained. Considering the dense nature of the material, results of direct shear tests on remolded soil samples were used to represent both the foundation soil and embankment/structural fill (to be constructed using the locally borrowed alluvium/colluvium). Figure 4-1 presents a summary of shear strengths tested on remolded foundation soils of the HLF, along with the strength envelope used for stability modeling. The comparison shows that an effective-stress strength represented by a cohesion of zero pounds per square foot (psf), and a friction angle of 36 degrees, is conservatively representative of foundation soil, embankment fill and structural fill. The strength of waste rock is based on the WRF stability memorandum by Wood (2021b).

The shear strength of the weakest material in the lined areas of the HLF will be the interfaces formed between the double sided textured geomembrane and the underliner layer (GCL). These interfaces were modeled based on previously performed testing on two different reinforced GCL products supplied by CETCO (Tetra Tech, 2007b; 2009b). The design of liner assembly remains the same, with the exception of the geomembrane thickness; Wood has proposed a thicker geomembrane liner, which should not affect shear strength. Post-peak or large displacement interface strength, in lieu of peak strength, has been used for this design, to account for potential displacement along liner interface to be caused during construction and stacking. Figure 4-2 shows the tested shear strengths versus the strength envelope that is used in this study; the figure demonstrates that the modeled shear strength of the liner interface is reasonably conservative to represent performance of the liner assembly under design conditions. The GCL and geomembrane selected for future construction should be equivalent to the products that have been evaluated in the previous designs (Tetra Tech, 2007b; 2009b) and suitable for use on sloped subgrades.

Consistent with Tetra Tech (2007b; 2009b), a non-linear strength criterion was used to represent shear strength of leach ore versus overburden pressure. Wood understands that both ROM and crushed ores will be stacked in the proposed HLF. All leach material is intended to achieve effective percolation under ultimate stacking height; therefore, the strength criterion that was used by Tetra Tech (2007b; 2009b) for the weakest type of rock fill in accordance with Leps (1970) is a reasonable representation of leach ore. This is shown in Figure 4-3 with a comparison of the modeled strength criterion versus measured rockfill shear strengths reported by Leps (1970).

The strength properties and average unit weights selected for different materials are presented in Table 4-1, along with supporting references for selection of properties.

Table 4-1: Material Prosperities Assigned for Stability Analyses

Material	Moist Unit Weight (pcf)	Effective Angle of Friction (degrees)	Cohesion / Adhesion (psf)	References
Foundation Soil	125	36	0	Tested Value (Note 1)
Embankment/Structural Fill	125	36	0	Tested Value (Note 1)
Overliner	125	36	0	Note 2
Waste Rock	135	37	0	Wood (2021b)
Leach Ore	125	38 (overburden<60’) 34 (overburden>60’)	0	Tetra Tech (2007b; 2009b)
Liner Interface	95	16.2	136	Adjusted based on Tetra Tech (2007b; 2009b)[3]

Notes: pcf = pounds force per cubic foot; psf = pounds force per square foot.
1. Tested strength value of this study; refer to Figure 4-1.
2. Assigned strength values based on review of existing testing data, similar projects in Arizona and literature search.
3. Post-peak strength has been used for this study based on testing results of Tetra Tech (2007b; 2009b), in lieu of peak strength.

4.5 Summary of Stability Analysis Results

The critical failure surfaces and corresponding factors of safety for static stability for all cases and all cross sections are presented in Figures 4-4 through 4-15. The factors of safety are summarized in Table 4-2. Table 4-2 also presents the design criteria for comparison.

Table 4-2: Summary of Limit Equilibrium Stability Results

Cross Section	Direction	Static Analyses		Min. BADCT Requirement, Static Analyses	Pseudo-static Analyses	Min. BADCT Requirement, Pseudo-static Analyses
		Circular Slip Surfaces	Linear Slip Surfaces			
HLF01	Downgradient	1.77	1.34	1.3	1.19	1.0
HLF02	Downgradient	1.91	1.56		1.39	
POND02	Downstream	1.54	NA		1.40	
	Upstream	1.89	NA		1.69	

Notes: NA = not applicable

5.0 Conclusions

All factors of safety exceed the minimum design criteria for static and pseudo-static conditions. The slope stability for the Rosemont HLF meets or exceed the acceptance criteria as required by ADEQ BADCT (ADEQ, 2004). During future stages of design, the interface shear strength under higher overburden pressure has to be further evaluated; and HLF grading plans should involve overall outward (or downgradient) slopes of liner subgrades under HLF side slopes (where applicable) no steeper than 6.5% in accordance with these analyses. In the future stages, there will be also required additional testing, analyses, ore-loading plans, operation, maintenance, and surveillance (OMS) and monitoring programs, including characterization of durability, permeability and strengths of ROM and crushed ore materials to verify assumptions and material properties stated in Sections 3.0 and 4.4 of this memorandum.

6.0 References

Arizona Department of Environmental Quality [ADEQ], (2004). *Arizona Mining BADCT Guidance Manual* (Publication #TB 04-01). Phoenix, Arizona.

Lettis Consultants International, [LCI], (2021), Site-Specific Seismic Hazard Analysis and Development of Design Ground Motions for Hudbay's Rosemont Pre-Feasibility Study, dated November 11, 2021.

Leps T, M. (1970), Review of Shearing Strength of Rockfill, Journal of the Soil Mechanics and Foundations Division, Proceedings of the American Society of Civil Engineers, Vol 96, No SM4, July 1970.

Hynes-Griffin, M.E. and Franklin, A.G. 1984. Rationalizing the Seismic Coefficient Method. Department of the Army.

Morgenstern, N.R., and Price, V.E. (1965), The Analysis of the Stability of General Slip Surfaces, Geotechnique, Vol. 15, pp. 79-93.

Rocscience (2021), *Slide2 software and manual*, Version 9.019, 2021.

Tetra Tech (2007a), *Geotechnical Study, Rosemont Copper,* prepared for Augusta Resource Corporation, by Tetra Tech, June 2007.

Tetra Tech (2007b), *Leaching Facilities Design*, prepared for Augusta Resource Corporation, by Tetra Tech, June 2007.

Tetra Tech (2009a), *Geotechnical Addendum, Rosemont Copper Project,* prepared for Rosemont Copper Company, by Tetra Tech, February 2009.

Tetra Tech (2009b), *Rosemont Heap Leach Facility Permit Design Report*, prepared for Rosemont Copper Company, by Tetra Tech, May 2009.

Tetra Tech (2010a), *Rosemont Heap Leach Pad Settlement Analysis,* prepared for Rosemont Copper Company, by Tetra Tech, August 11, 2010.

Tetra Tech (2010b), *Rosemont Heap Leach Facility Permit Design Liner Leakage Calculations,* prepared for Rosemont Copper Company, by Tetra Tech, August 20, 2010.

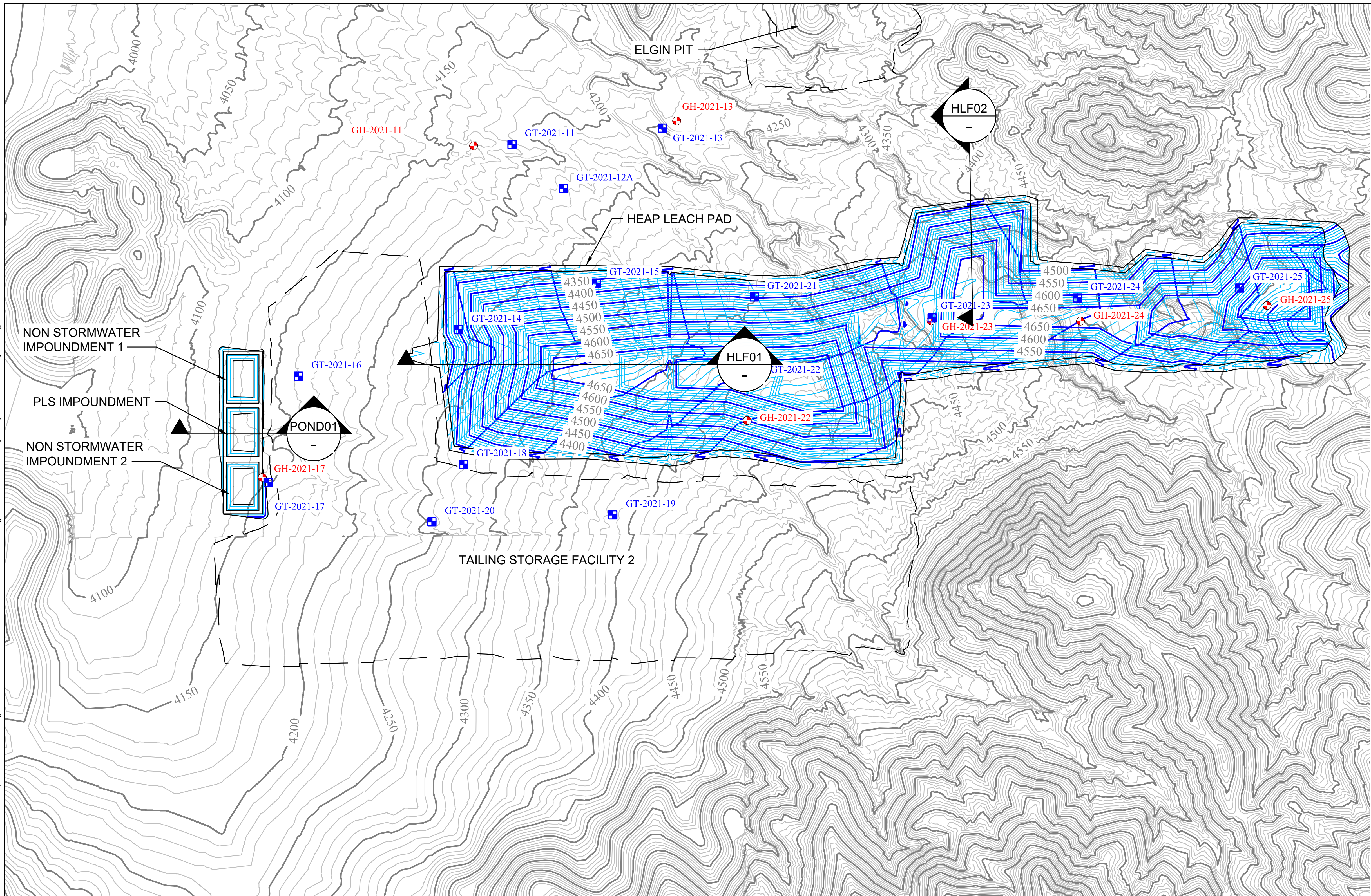
Wood (2021a), *Geotechnical Site Investigation Memorandum, Heap Leach, Tailings and Waste Rock Facilities, Rosemont Copper World Project,* prepared for Rosemont Copper Company, by Wood, December 1.

Wood (2021b), *Stability Analysis Memorandum, Waste Rock Facility, Rosemont Copper World Project,* prepared for Rosemont Copper Company, by Wood, November 29.

ACRONYMS AND ABBREVIATIONS

%	%
A.A.C	Arizona Administrative Code
ADEQ	Arizona Department of Environmental Quality
APP	Aquifer Protection Permit
A.R.S.	Arizona Revised Statute
BADCT	Best Available Demonstrated Control Technology
cm/sec	Centimeters per Second
ft	Feet/Foot
FoS	Factor of Safety
GCL	geosynthetic clay liner
HDPE	High-Density Polyethylene
HLF	Heap Leach Facility
HLP	Heap Leach Pad
LCI	Lettis Consultants International
LLDPE	Linear Low-Density Polyethylene
mil	Millimeter
MPE	Maximum Probable Earthquake
m/s	Meters per Second
OMS	Operation, Maintenance, and Surveillance
PFS	Pre-Feasibility study
PGA	Peak Ground Acceleration
PLS	Pregnant Leach Solution
pcf	Pound per Cubic Foot
Project	Rosemont Copper World Project
psf	Pound per Square Foot
ROM	Run-of-Mine
Rosemont	Rosemont Copper Company
TSF	Tailings Storage Facility
Wood	Wood Environment & Infrastructure Solutions, Inc.
WRF	Waste Rock Facility

FIGURES



LEGEND:

●	GH-2021-01	BOREHOLE
■	GT-2021-01	TEST PIT

N

0 1000' 2000'

HLP PLAN

SCALE: 1"=1000'

ROSEMONT COPPER WORLD PROJECT
PFS DESIGN
STABILITY ANALYSES HLP
SITE LAYOUT

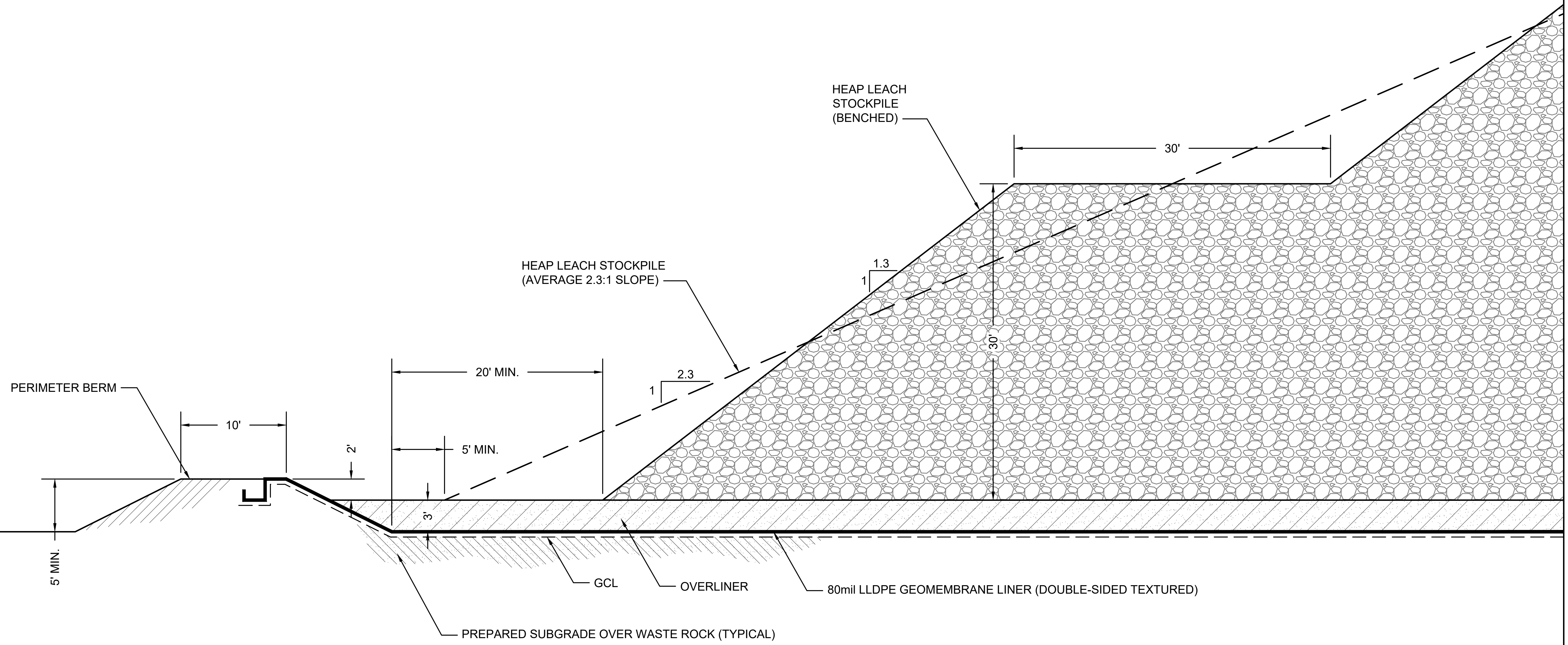
wood.

WOOD ENVIRONMENT & INFRASTRUCTURE SOLUTIONS
4600 E WASHINGTON ST, SUITE 600
PHOENIX, ARIZONA 85034
PHONE: 602-733-6000

Figure: 1-1

By: GG | Date: 01/12/21 | Project No: 17-2021-4024

wood. Drawing Path: P:\2021\Projects_Other\17202214024.001_Rosemont Project\13_CAD\03_Figures\004 - 30-11-2021 - HLF Stab Sections\, Drawing Name: FIG 1 Stability Analyses HLP Site Layout.dwg Plot Date: 12/01/21 - 11:18am



0 10' 20'

TYPICAL HLP PERIMETER BERM

SCALE: 1"=10'

ROSEMONT COPPER WORLD PROJECT
PFS DESIGN
STABILITY ANALYSES HLP
TYPICAL PERIMETER BERM

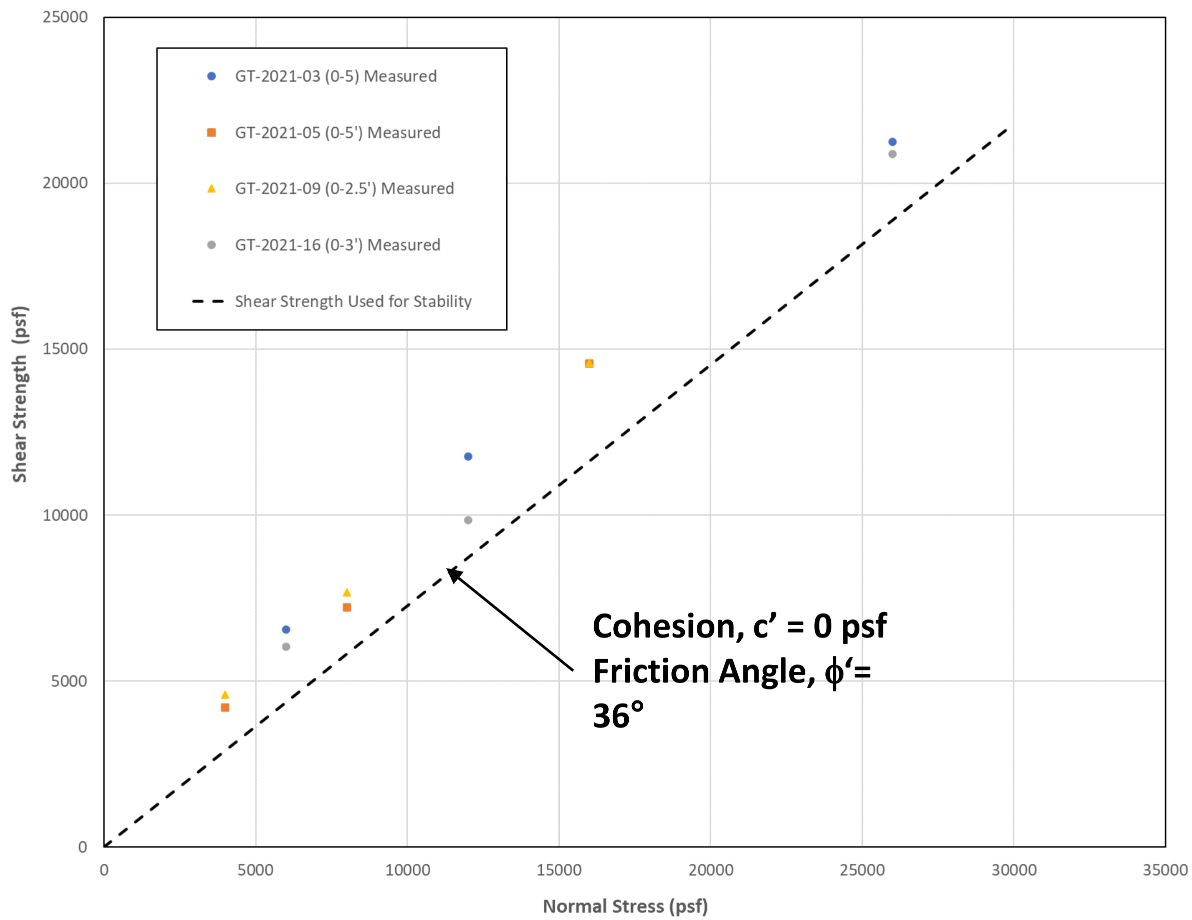
wood.

WOOD ENVIRONMENT & INFRASTRUCTURE SOLUTIONS
4600 E WASHINGTON ST, SUITE 600
PHOENIX, ARIZONA 85034
PHONE: 602-733-6000

Figure: 1-2

By: OAS | Date: 12/01/21 | Project No: 17-2021-4024

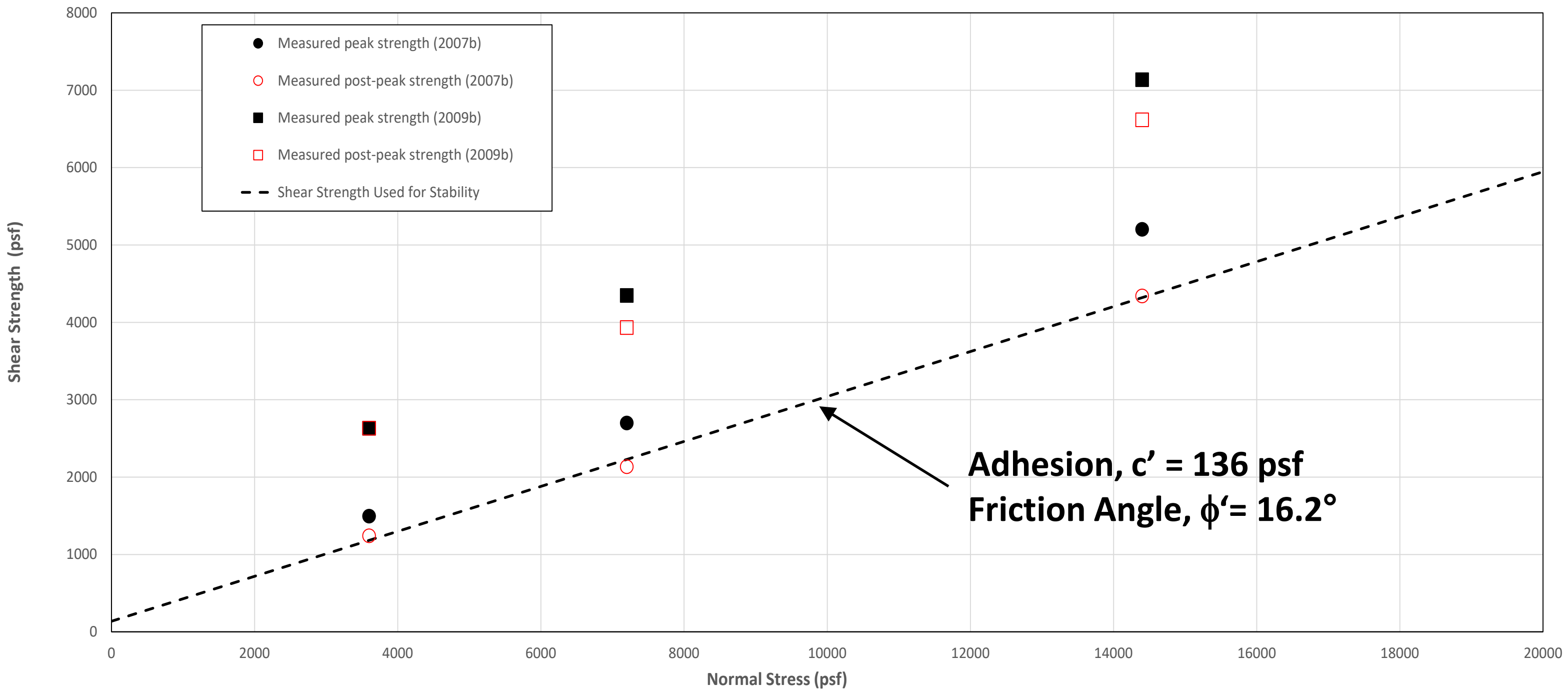
wood Drawing Path: P:\2021\Projects_Other\1720214024.001_Rosemont Project\13_CAD\03_Figures\004 - 30-11-2021 - HLF Stab Sections\, Drawing Name: FIG 1-2 HLP MEMO TYP BERM SECTION.dwg Plot Date: 12/06/21 - 3:22pm



Shear Strength Used for Modeling versus Direct Shear Test Results

- **Foundation Soil**
- **Embankment and Structural Fill**

Rosemont Copper Company	Rosemont Copper World Project PFS Design – HLF Stability Analyses	
Summary of Direct Shear Tests on Foundation Soils		
wood. **Wood Environment & Infrastructure Solutions, Inc.**	Figure 4-1 PROJECT NUMBER 17-2021-4024 SCALE: N/A DATE: Dec 2021	



Shear Strengths Tested on Liner Interface with the following material (2007b)

- **CETCO Bentomat CL GCL**
- **Agru America 60 mil LLDPE (textured)**

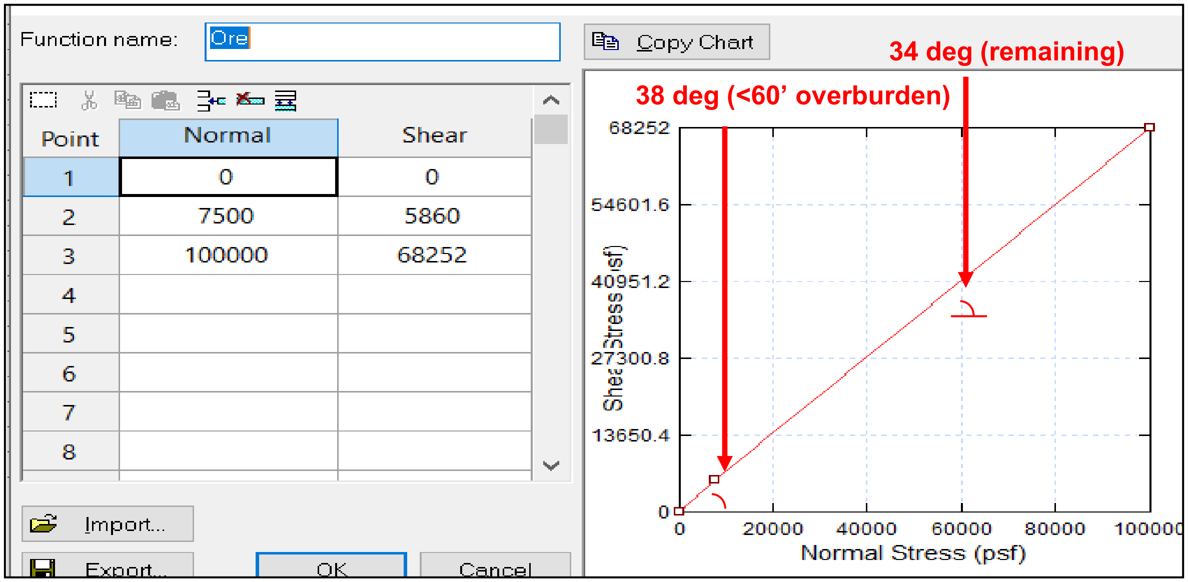
Shear Strengths Tested on Liner Interface with the following material (2009b)

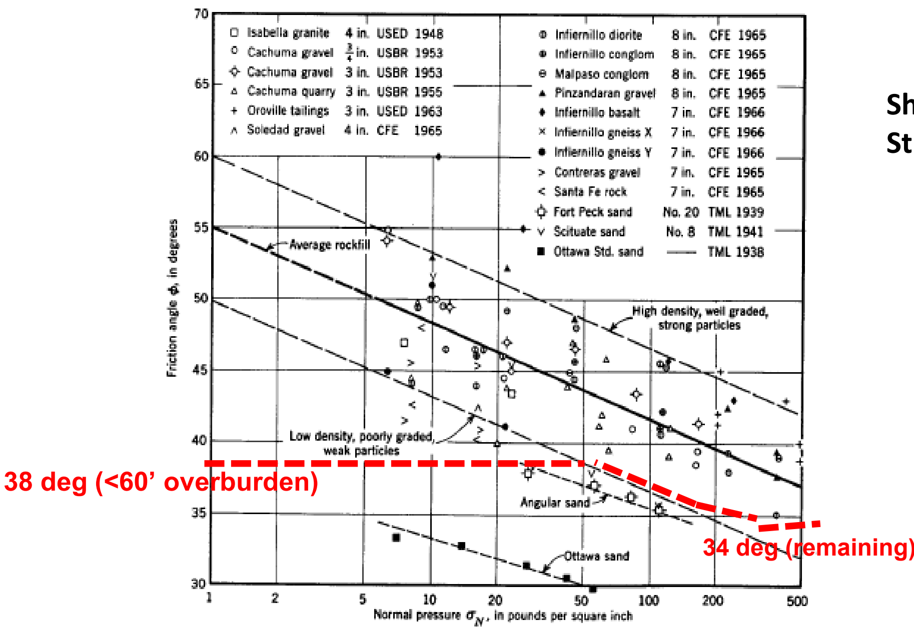
- **CETCO Bentomat DN GCL**
- **60 mil LLDPE (textured)**

Testing results duplicated from Tetra Tech (2007b), Leaching Facilities Design, prepared for Augusta Resource Corporation, by Tetra Tech, June 2007; and Tetra Tech (2009b), Rosemont Heap Leach Facility Permit Design Report, prepared for Rosemont Copper Company, by Tetra Tech, May 2009.

Rosemont Copper Company	Rosemont Copper World Project PFS Design – HLF Stability Analyses
HLF Liner Interface Shear Strength	
wood. **Wood Environment & Infrastructure Solutions, Inc.**	Figure 4-2 PROJECT NUMBER: 17-2021-4024 SCALE: N/A DATE: Dec 2021

Ore Shear Strength Used for Modeling

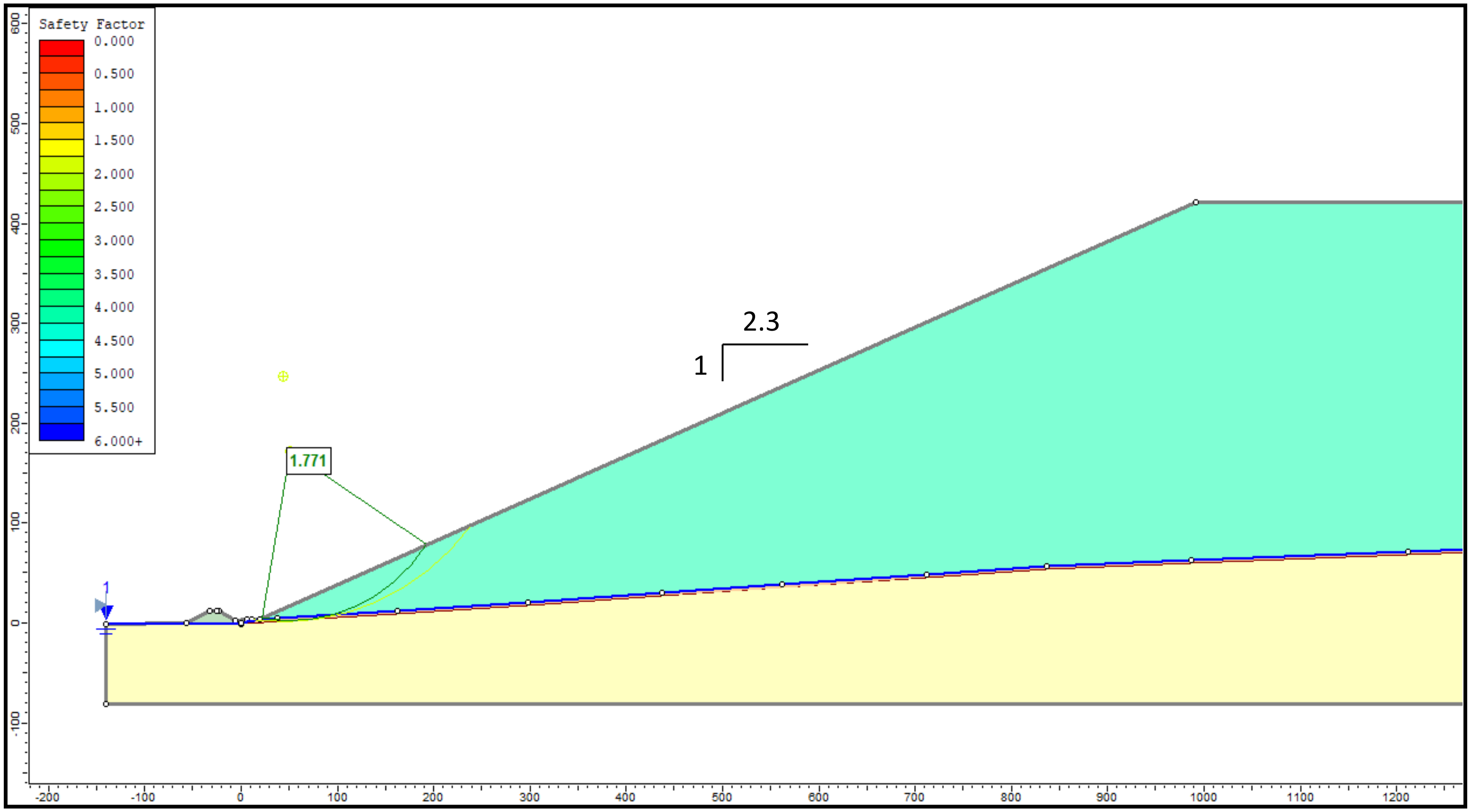




Shear Strengths Modelled versus Reported Rockfill Strengths (Leps, 1970)

Chart to the left reproduced from Leps, 1970, Review of Shearing Strength of Rockfill, Journal of the Soil Mechanics and Foundations Division, Proceedings of the American Society of Civil Engineers, Vol 96, No SM4, July 1970.

Rosemont Copper Company	Rosemont Copper World Project PFS Design – HLF Stability Analyses
HLF Ore Strength	
wood. **Wood Environment & Infrastructure Solutions, Inc.**	Figure 4-3 PROJECT NUMBER: 17-2021-4024 SCALE: N/A DATE: Dec 2021



Static Condition
Circular Failure (failure envelopes with min. 10 FOS shown)
Minimum FOS = 1.77

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface	Ru
Foundation Soil		125	Mohr-Coulomb	0	36		None	0
Embankment Fill		125	Mohr-Coulomb	0	36		None	0
Overliner		125	Mohr-Coulomb	0	36		Piezometric Line 1	
Ore		125	Shear Normal function			Ore	None	0
Liner and GCL		95	Mohr-Coulomb	136	16.2		None	0

Rosemont Copper Company

Rosemont Copper World Project
PFS Design – HLF
Stability Analyses

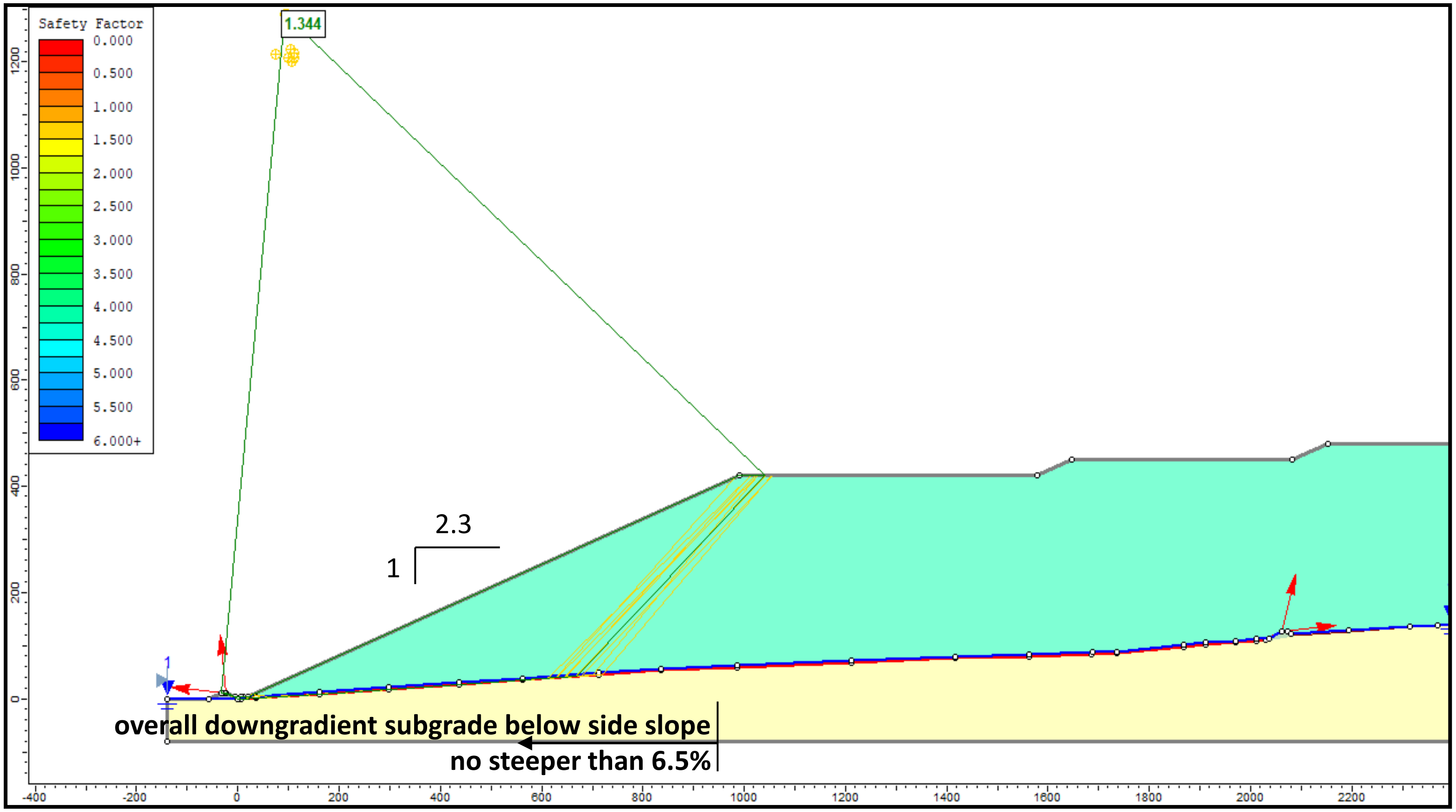
Section HLF01 – Static

Wood Environment & Infrastructure Solutions, Inc.

Figure 4-4

PROJECT NUMBER: 17-2021-4024

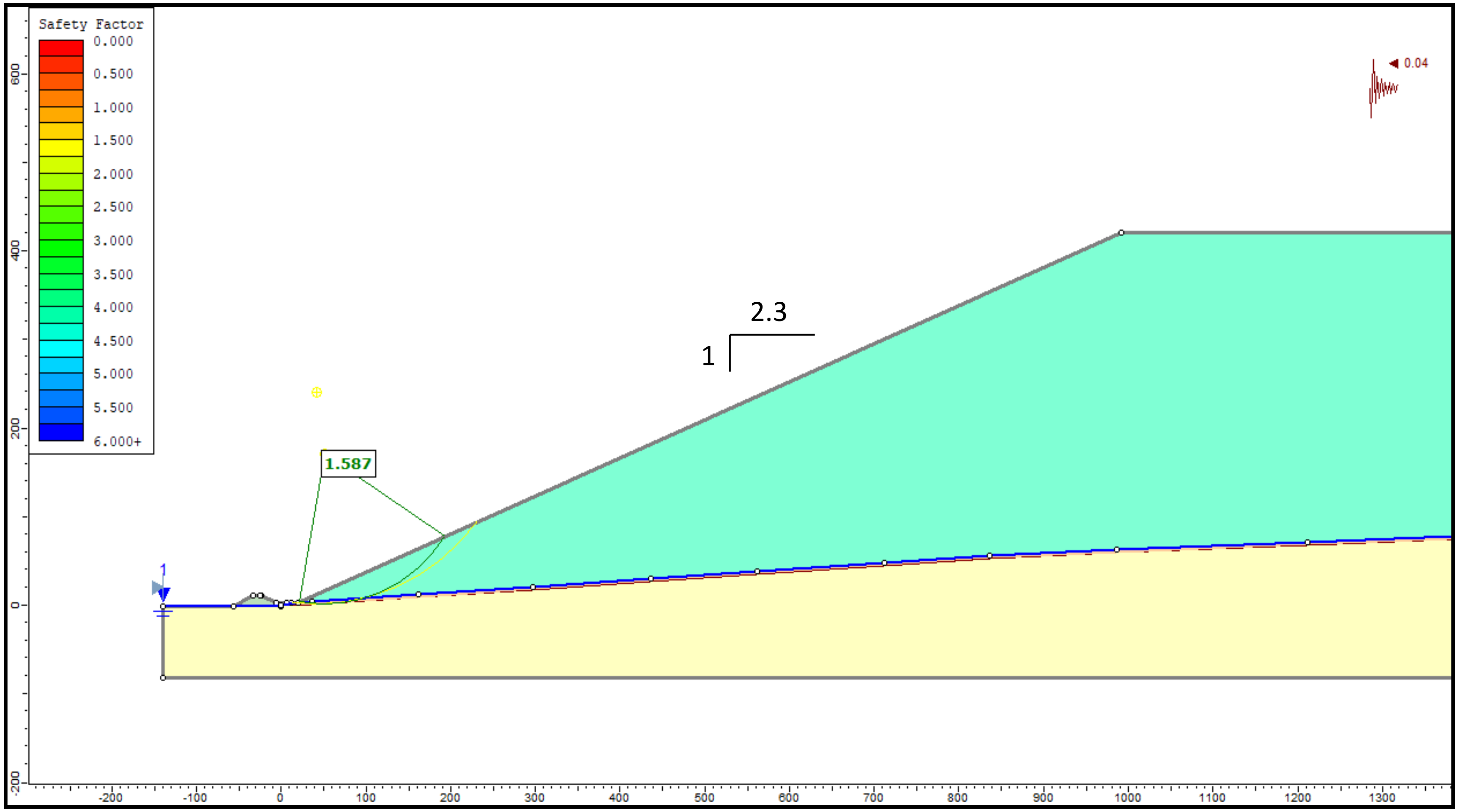
SCALE: N/A DATE: Dec 2021



Static Condition
Non-Circular (failure envelopes with 10 min. FOS shown)
Minimum FOS = 1.34

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface	Ru
Foundation Soil		125	Mohr-Coulomb	0	36		None	0
Embankment Fill		125	Mohr-Coulomb	0	36		None	0
Overliner		125	Mohr-Coulomb	0	36		Piezometric Line 1	
Ore		125	Shear Normal function			Ore	None	0
Liner and GCL		95	Mohr-Coulomb	136	16.2		None	0

Rosemont Copper Company	Rosemont Copper World Project PFS Design – HLF Stability Analyses
Section HLF01 – Static	
wood. **Wood Environment & Infrastructure Solutions, Inc.**	Figure 4-5 PROJECT NUMBER: 17-2021-4024 SCALE: N/A DATE: Dec 2021



Pseudo-Static Condition (k= 0.04g)
Circular Failure (failure envelopes with 10 min. FOS shown)
Minimum FOS = 1.59

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface	Ru
Foundation Soil		125	Mohr-Coulomb	0	36		None	0
Embankment Fill		125	Mohr-Coulomb	0	36		None	0
Overliner		125	Mohr-Coulomb	0	36		Piezometric Line 1	
Ore		125	Shear Normal function			Ore	None	0
Liner and GCL		95	Mohr-Coulomb	136	16.2		None	0

Rosemont Copper Company

Rosemont Copper World Project
PFS Design – HLF
Stability Analyses

Section HLF01 – Pseudo-Static

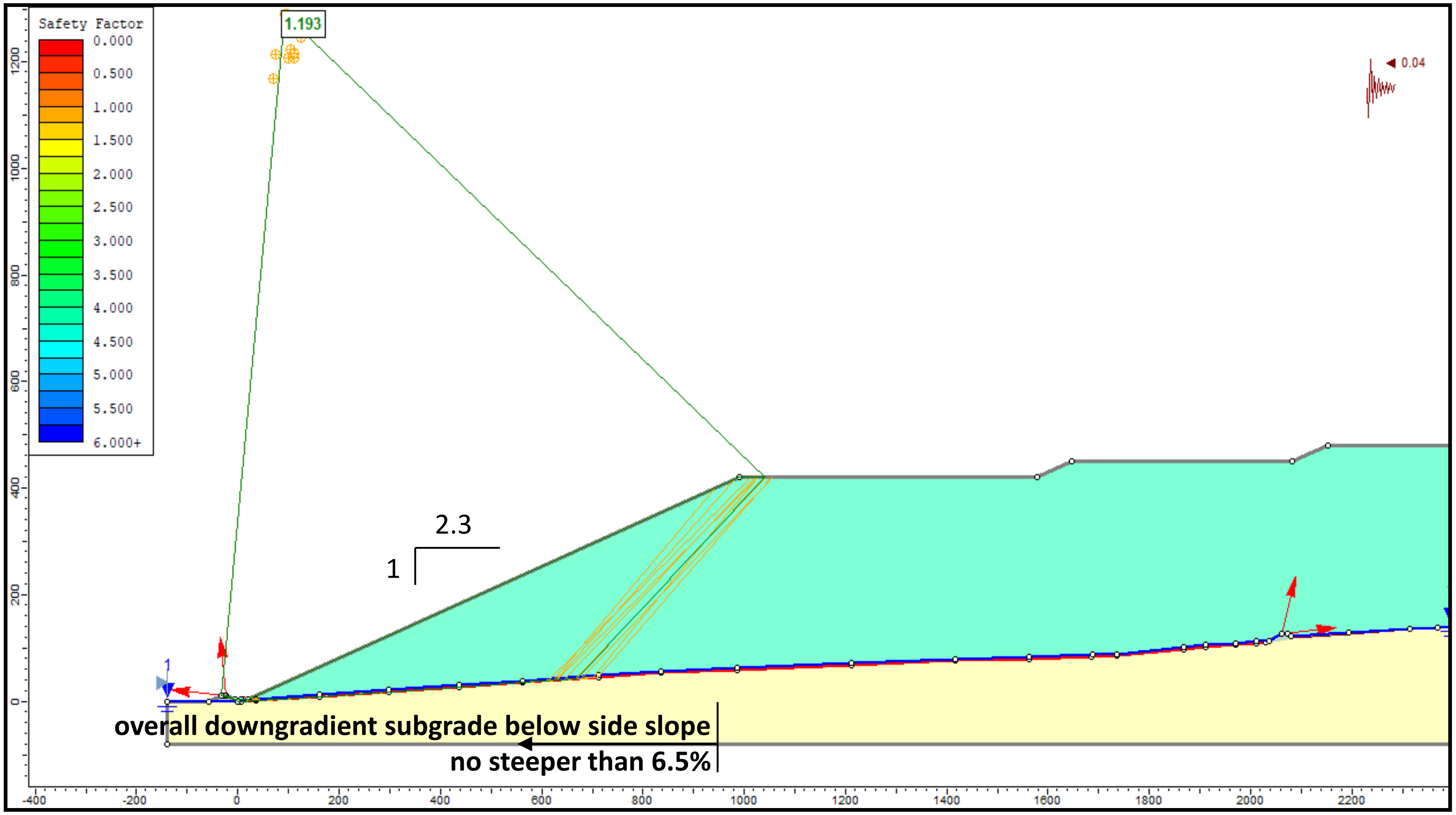
wood. **Wood Environment & Infrastructure Solutions, Inc.**

Figure 4-6

PROJECT NUMBER: 17-2021-4024

SCALE: N/A

DATE: Dec 2021



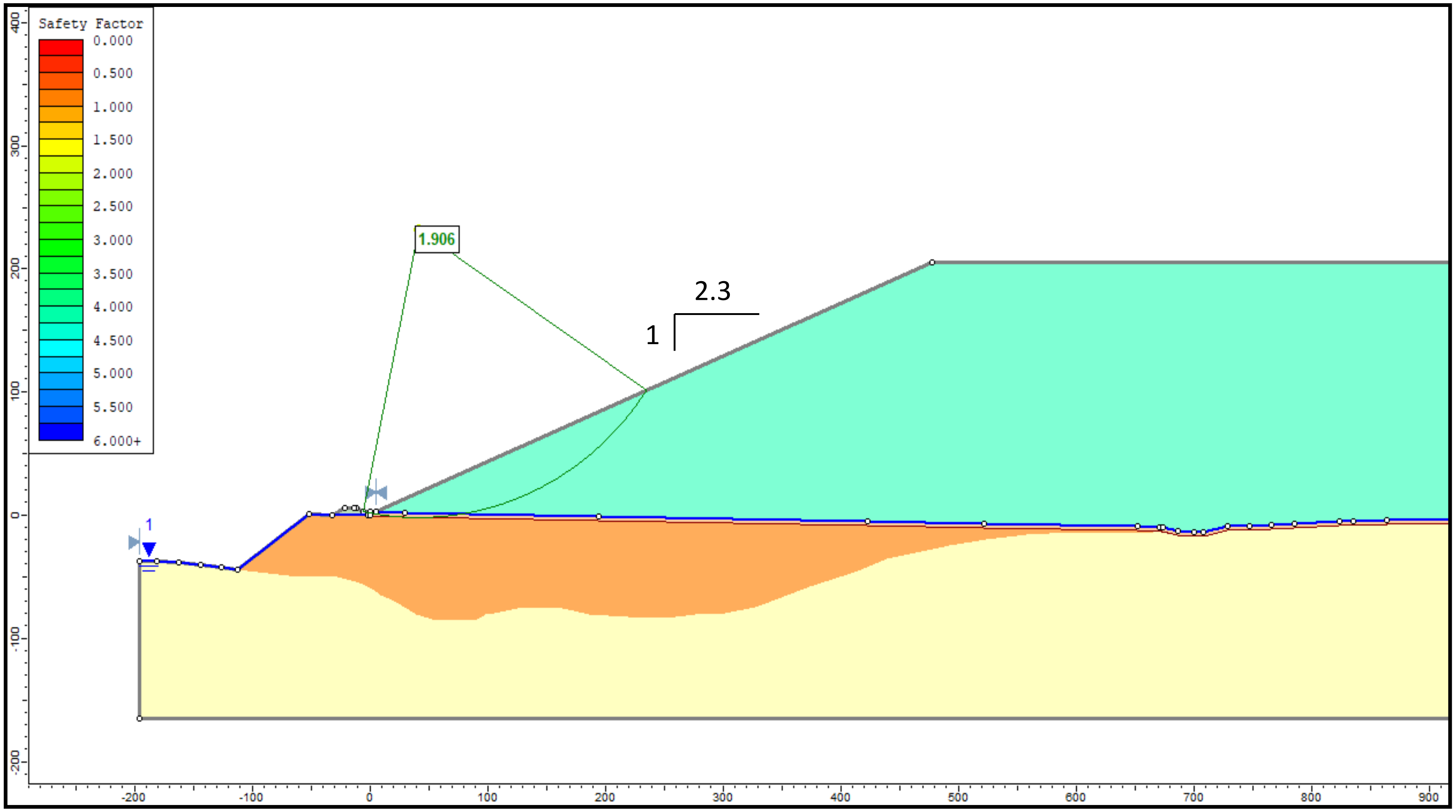
Pseudo-Static Condition (k= 0.04g)
Non-Circular (failure envelopes with 10 min. FOS shown)
Minimum FOS = 1.19

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface	Ru
Foundation Soil		125	Mohr-Coulomb	0	36		None	0
Embankment Fill		125	Mohr-Coulomb	0	36		None	0
Overliner		125	Mohr-Coulomb	0	36		Piezometric Line 1	
Ore		125	Shear Normal function			Ore	None	0
Liner and GCL		95	Mohr-Coulomb	136	16.2		None	0

Rosemont Copper Company	Rosemont Copper World Project PFS Design – HLF Stability Analyses

Section HLF01 – Pseudo-Static

wood. **Wood Environment & Infrastructure Solutions, Inc.**	Figure 4-7			
	PROJECT NUMBER:	17-2021-4024		
	SCALE:	N/A	DATE:	Dec 2021



Static Condition
Circular Failure (failure envelopes with 10 min. FOS shown)
Minimum FOS = 1.91

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface	Ru
Foundation Soil		125	Mohr-Coulomb	0	36		None	0
Embankment Fill		125	Mohr-Coulomb	0	36		None	0
Overliner		125	Mohr-Coulomb	0	36		Piezometric Line 1	
Waste Rock		135	Mohr-Coulomb	0	37		None	0
Ore		125	Shear Normal function			Ore	None	0
Liner and GCL		95	Mohr-Coulomb	100	16		None	0

Rosemont Copper Company

Rosemont Copper World Project
PFS Design – HLF
Stability Analyses

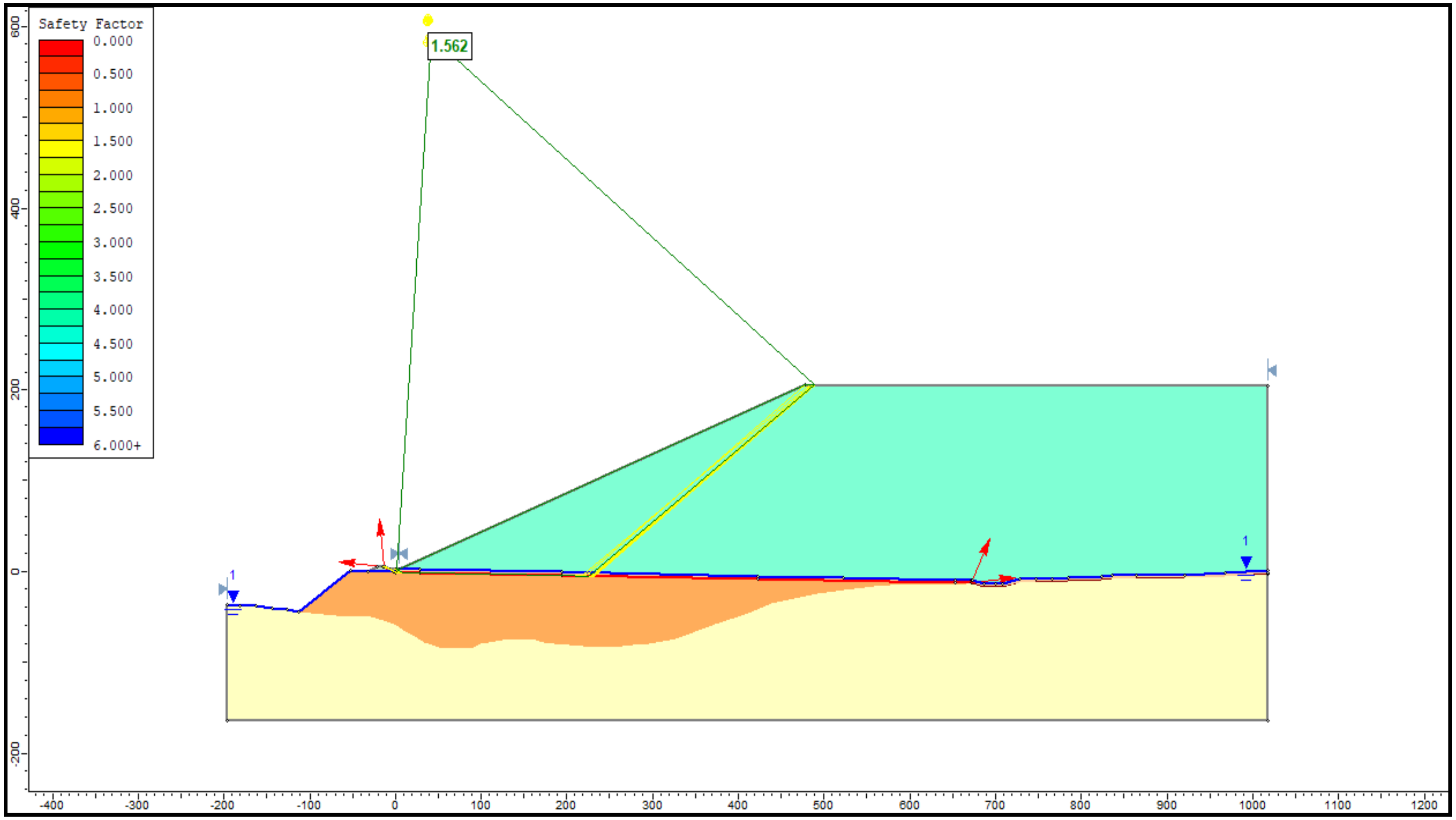
Section HLF02 – Static

wood. **Wood Environment & Infrastructure Solutions, Inc.**

Figure 4-8

PROJECT NUMBER: 17-2021-4024

SCALE: N/A DATE: Dec 2021



Static Condition

Non-Circular (failure envelopes with 10 min. FOS shown)

Minimum FOS = 1.56

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface	Ru
Foundation Soil		125	Mohr-Coulomb	0	36		None	0
Embankment Fill		125	Mohr-Coulomb	0	36		None	0
Overliner		125	Mohr-Coulomb	0	36		Piezometric Line 1	
Waste Rock		135	Mohr-Coulomb	0	37		None	0
Ore		125	Shear Normal function			Ore	None	0
Liner and GCL		95	Mohr-Coulomb	100	16		None	0

Rosemont Copper Company

Rosemont Copper World Project
PFS Design – HLF
Stability Analyses

Section HLF02 – Static

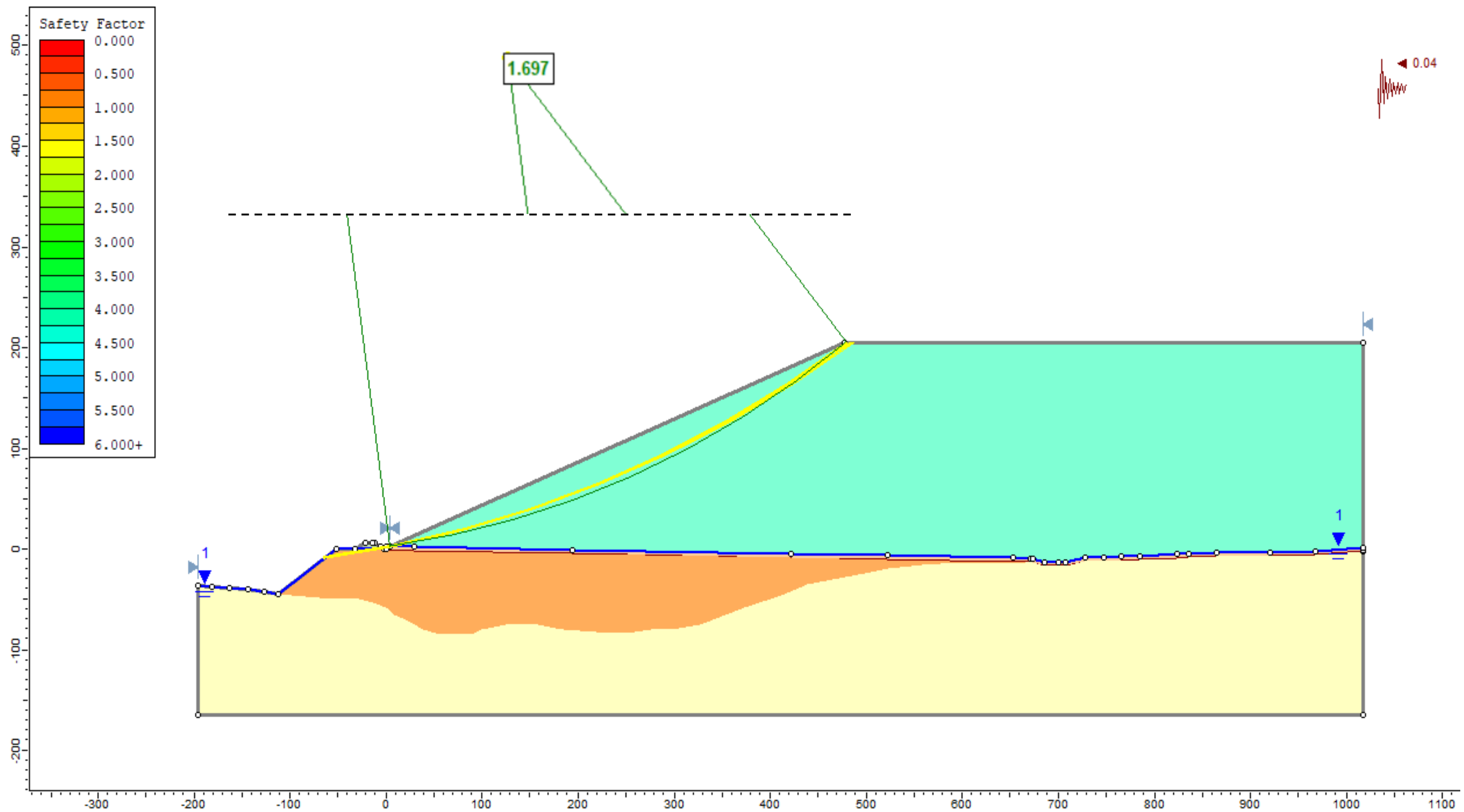
wood. **Wood Environment & Infrastructure Solutions, Inc.**

Figure 4-9

PROJECT NUMBER: 17-2021-4024

SCALE: N/A DATE: Dec 2021

RCC-CW004019



Static Condition

Circular Failure (failure envelopes with 10 min. FOS shown)

Minimum FOS = 1.70

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface	Ru
Foundation Soil		125	Mohr-Coulomb	0	36		None	0
Embankment Fill		125	Mohr-Coulomb	0	36		None	0
Overliner		125	Mohr-Coulomb	0	36		Piezometric Line 1	
Waste Rock		135	Mohr-Coulomb	0	37		None	0
Ore		125	Shear Normal function			Ore	None	0
Liner and GCL		95	Mohr-Coulomb	100	16		None	0

Rosemont Copper Company

Rosemont Copper World Project
PFS Design – HLF
Stability Analyses

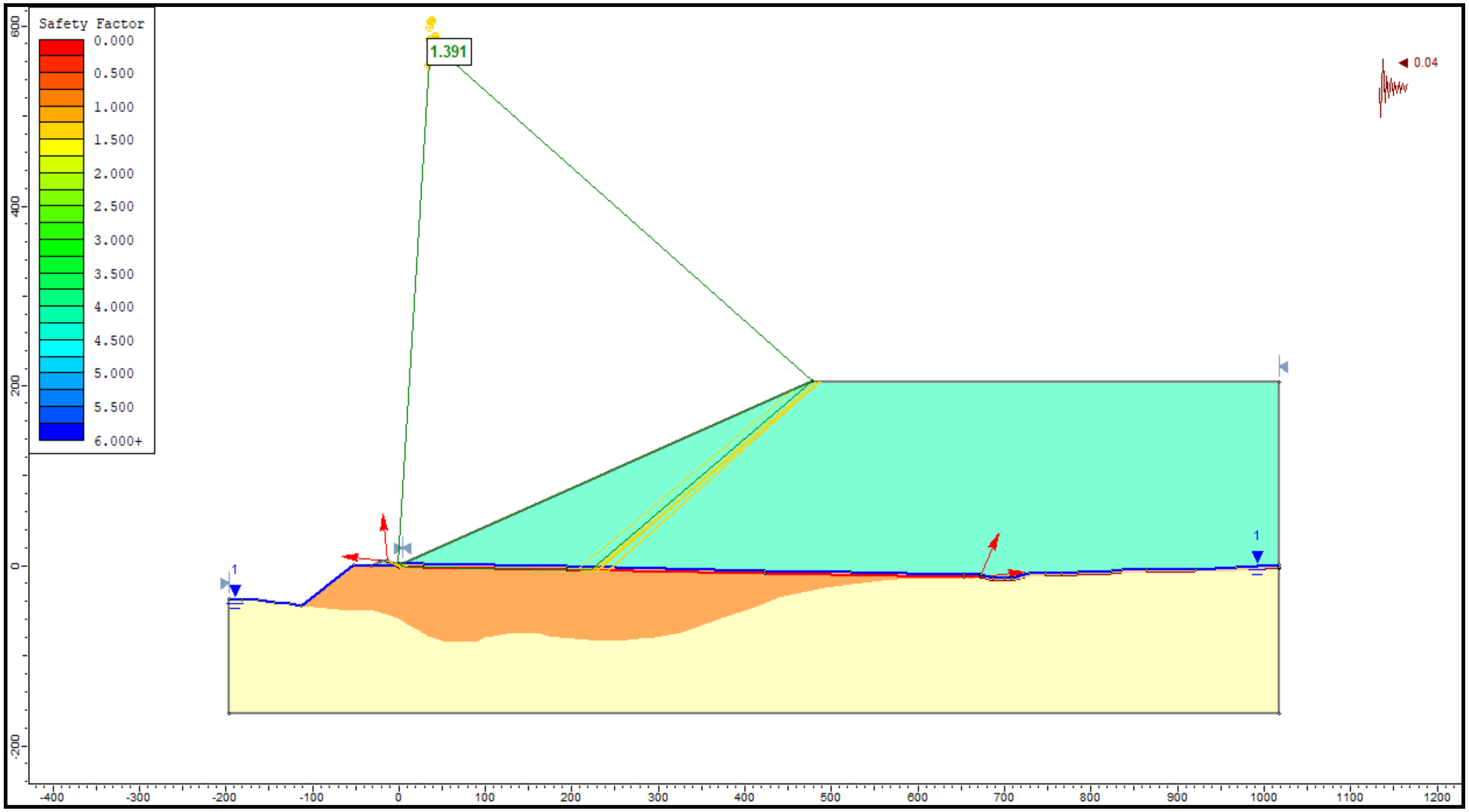
Section HLF02 – Pseudo-Static

wood. **Wood Environment & Infrastructure Solutions, Inc.**

Figure 4-10

PROJECT NUMBER: 17-2021-4024

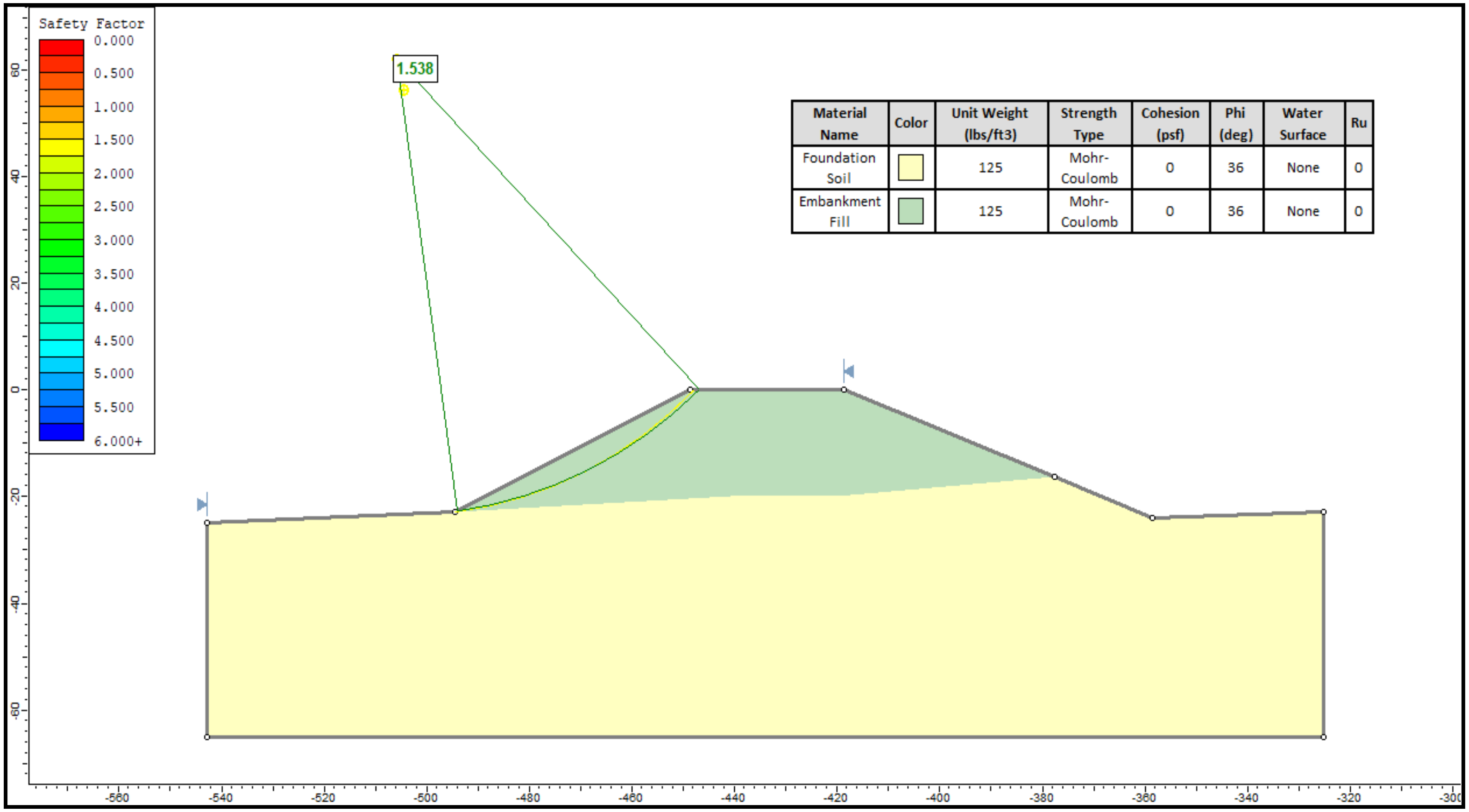
SCALE: N/A DATE: Dec 2021



Static Condition
Non-Circular (failure envelopes with 10 min. FOS shown)
Minimum FOS = 1.39

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface	Ru
Foundation Soil		125	Mohr-Coulomb	0	36		None	0
Embankment Fill		125	Mohr-Coulomb	0	36		None	0
Overliner		125	Mohr-Coulomb	0	36		Piezometric Line 1	
Waste Rock		135	Mohr-Coulomb	0	37		None	0
Ore		125	Shear Normal function			Ore	None	0
Liner and GCL		95	Mohr-Coulomb	100	16		None	0

Rosemont Copper Company	Rosemont Copper World Project PFS Design – HLF Stability Analyses
Section HLF02 – Pseudo-Static	
wood. **Wood Environment & Infrastructure Solutions, Inc.**	Figure 4-11 PROJECT NUMBER: 17-2021-4024 SCALE: N/A DATE: Dec 2021



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Foundation Soil		125	Mohr-Coulomb	0	36	None	0
Embankment Fill		125	Mohr-Coulomb	0	36	None	0

Section POND01 Downstream Direction
Static Condition – Circular Failure
Minimum FOS = 1.54

Rosemont Copper Company

Rosemont Copper World Project
PFS Design – HLF
Stability Analyses

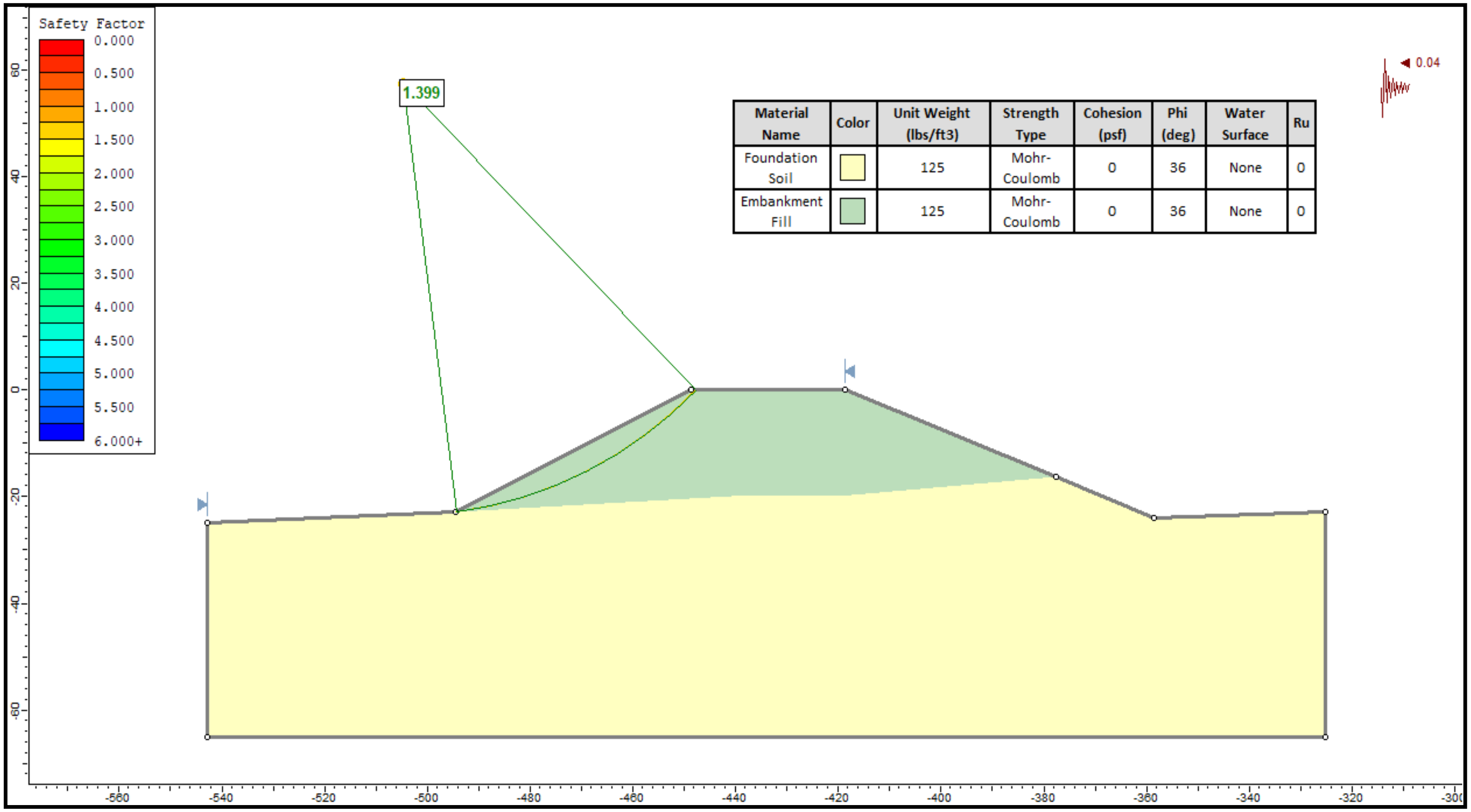
Section POND01 Downstream – Static

wood. **Wood Environment & Infrastructure Solutions, Inc.**

Figure 4-12

PROJECT NUMBER: 17-2021-4024

SCALE: N/A DATE: Dec 2021

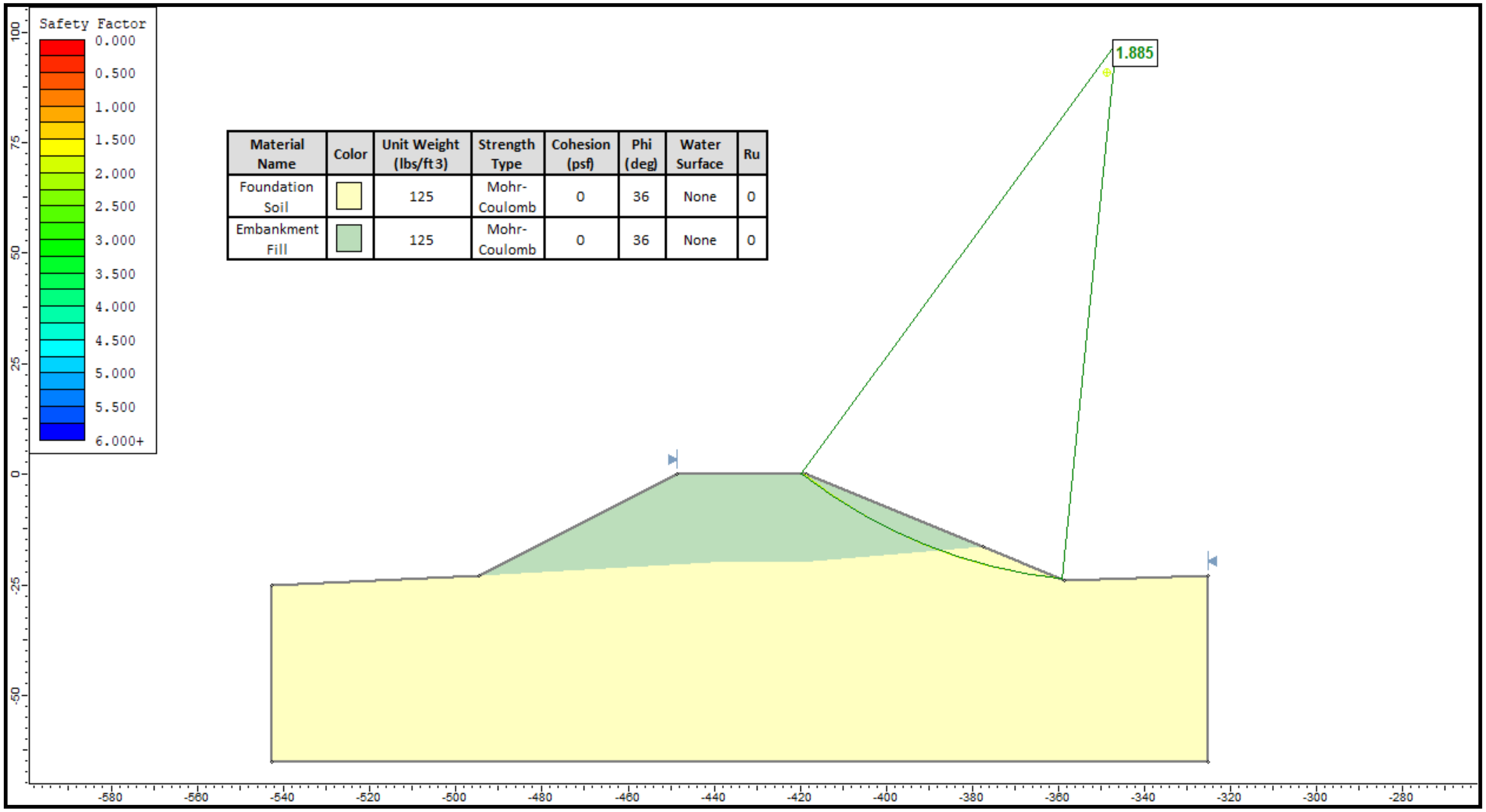


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Foundation Soil		125	Mohr-Coulomb	0	36	None	0
Embankment Fill		125	Mohr-Coulomb	0	36	None	0

Section POND01 Downstream Direction
Pseudo-Static Condition – Circular Failure
Minimum FOS = 1.40

Rosemont Copper Company	Rosemont Copper World Project PFS Design – HLF Stability Analyses
Section POND01 Downstream – Pseudo-Static	
wood. **Wood Environment & Infrastructure Solutions, Inc.**	Figure 4-13 PROJECT NUMBER: 17-2021-4024 SCALE: N/A DATE: Dec 2021

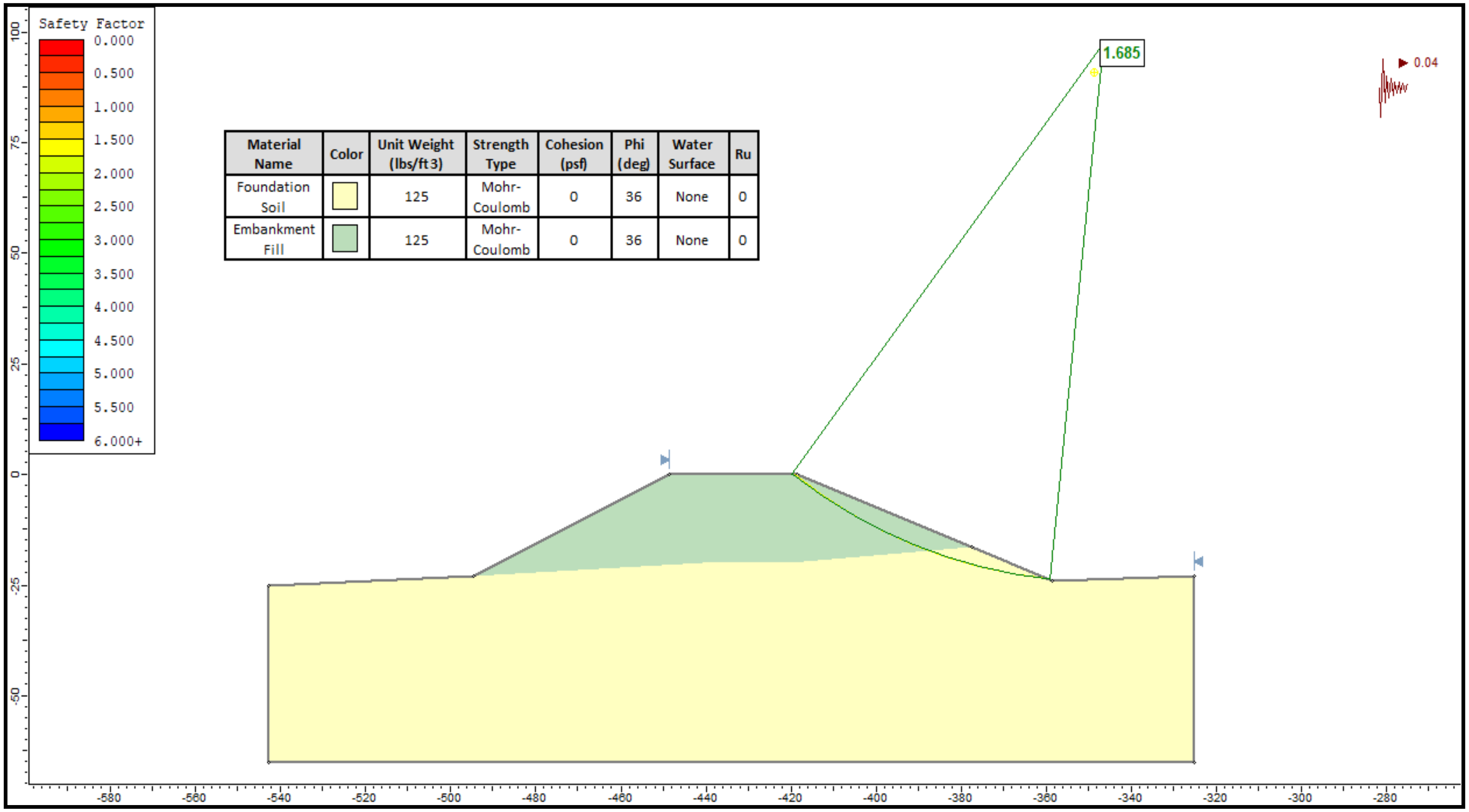
RCC-CW004023



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Foundation Soil		125	Mohr-Coulomb	0	36	None	0
Embankment Fill		125	Mohr-Coulomb	0	36	None	0

Section POND01 Upstream Direction
Static Condition – Circular Failure
Minimum FOS = 1.89

Rosemont Copper Company	Rosemont Copper World Project PFS Design – HLF Stability Analyses
Section POND01 Upstream – Static	
wood. **Wood Environment & Infrastructure Solutions, Inc.**	Figure 4-14 PROJECT NUMBER: 17-2021-4024 SCALE: N/A DATE: Dec 2021



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Foundation Soil		125	Mohr-Coulomb	0	36	None	0
Embankment Fill		125	Mohr-Coulomb	0	36	None	0

Section POND01 Upstream Direction
Pseudo-Static Condition – Circular Failure
Minimum FOS = 1.69

Rosemont Copper Company	Rosemont Copper World Project PFS Design – HLF Stability Analyses

Section POND01 Upstream – Pseudo-Static

wood. **Wood Environment & Infrastructure Solutions, Inc.**	Figure 4-15	
	PROJECT NUMBER: 17-2021-4024	
	SCALE: N/A	DATE: Dec 2021